

# STC Research Project Description

**Project Title:** A Simulation Model for Vulnerability Analysis of Seaports

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**Project Start Date:** March 15, 2003

**End Date:** March 14, 2004

**Other Milestones, Dates:**

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## **Project Objective:**

The objective of this proposed research is to develop the framework of a methodology for measuring the vulnerability of seaports, which handle international marine containers, to the threat that terrorists may import dangerous products contained inside marine containers. The proposed research will explore various aspects of a simulation model for analyzing the various stages of a container's movement and the effectiveness of different countermeasures that are being implemented for detecting such an attempt.

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## **Project Abstract:**

Since the tragic events of September 11<sup>th</sup>, 2001 the security of the multimodal national transportation system, which includes many subsystems/components, has become a major concern because the transportation system can be a target of terrorism and also it can be used to import weapons of mass destruction. The objective of this proposed research is to develop the framework of a methodology for measuring the vulnerability of one component of the national transportation system – seaports, which handle international marine containers. There is a serious concern that terrorists may try to import a dangerous product contained inside a marine container through a port undetected and then use it in a location where a great deal of harm can be done. The methodology to be explored will involve a simulation model for analyzing the various stages of a container's movement and the effectiveness of different inspections and checks that are made by different agencies.

With this seed grant a framework of the model will be developed and tested, and this work can be shown to other agencies for seeking a larger grant for further refinements and applications. The generic structure and approach to be developed would be applicable to other facilities such as airports.

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## **Task Description:**

**Task A: Gather and review information on past and ongoing research on 'vulnerability' assessment.**

The issue of 'vulnerability' of a facility and/or service to intentional (i.e. preplanned) activities is not new. The military has to deal with this issue continuously. Certain civilian facilities such as nuclear

plants also are subject to the infiltration by criminals and terrorists. Therefore, different public and private agencies have performed 'vulnerability' analysis in the past, and although some of the specific information may be 'classified', some information regarding the methodology of analysis may be available from selected organizations and articles published. It should be recognized that the subject of 'reliability analysis', which is a special area within statistics as well as industrial engineering has a lot of similarity with vulnerability analysis. Another subject area that is very relevant to this project is risk-based decision making (RBDM). The proposed research project will begin with a thorough search of literature in all relevant subject areas, and the investigators are aware of several publications on these subjects. It should be pointed out that the vulnerability to be analyzed by this project has a special context, which may not match with all types of vulnerability cases.

#### **Task B: Schedule visit to one selected port**

One very important aspect of this proposal will be to learn the details of the physical and operational system of seaports. Although the members of the research team are familiar with the design and operation of seaports, they will seek the help of experts to learn the intricate details with regard to security. The investigators will organize a port tour and meetings with port officials of one port as well as officials of U.S. Customs and The Coast Guard. The Executive Director of North Carolina State Ports Authority, which operates two ports at Wilmington and Morehead City, has been contacted about this research. He has endorsed the project and agreed to cooperate fully with the researchers. It is anticipated that the Port of Wilmington, NC, will be used for this research as the primary port to study.

#### **Task C: Develop a detailed flow chart of the operational and physical components of a seaport.**

The researchers will map out a detailed flow-chart of the physical as well as the functional components of a port. These two flow-charts will be combined or superimposed for certain analyses. As mentioned in Task B the researchers will visit a port and seek the assistance of the officials of ports and agencies such as U.S. Customs and the U.S. Coast Guard for enhancing their understanding. The development of flow-charts will be followed by the identification of the users and/or personnel who use and/or interact with each of the components of the operational and physical systems.

This task will be performed in great detail and the information that will be developed will provide the structure and basis for the subsequent analysis of vulnerability. It should be added that the initial flow-chart may be revised a few times during the course of the study based on the findings and requirements of subsequent tasks.

#### **Task D: Develop the analytical structure and statistical formulation for vulnerability analysis.**

This task will be devoted to addressing and resolving various issues related to the analytical structure and statistical formulation of estimating a composite vulnerability index for a seaport related to the passage of a dangerous container through the port. The entire movement of an international marine container imported from a foreign country is complex. It consists of numerous links, nodes and parties/actors. The passage through a seaport in the USA is a small but critical part of the entire chain and this project will deal with this portion only. A variety of measures are being implemented by US Customs, US Coast Guard, and port officials to identify a dangerous container. For example, in addition to the use of x-ray machines to screen containers, the identity of shippers and receivers is being verified by customs officials. Coast Guard officials also are boarding incoming ships for

inspecting ships and crews. The simulation model will include such parameters as ‘percent of containers x-rayed’, ‘proportion of arriving containers that may contain dangerous cargo’, and others to represent each strategy. The model structure will allow different scenarios to be developed by varying the values of different parameters. One of the members of the research team, Dr. Rupy Sawhney, has analyzed ‘real world’ problems faced by different industrial firms, which have a lot of similarities with the problem of detecting a dangerous cargo going through a port. The methodologies for analyzing these problems involving the reliability of production processes are applicable to evaluating and improving the reliability of a port to detect a suspect container with its inspection processes with certain modifications.

**Task E: Develop the framework of the simulation model for a specific port**

The Port of Wilmington, NC, will be used to generate a realistic scenario for the simulation model. The Executive Director of the North Carolina State Ports Authority, Erik Stromberg, has agreed to cooperate with the efforts of this project. (He has communicated his endorsement via an e-mail written to Dr. Arun Chatterjee, PI of the project.) The data to be input in the model may not be the actual values for the port for reasons of confidentiality, but they would be realistic.

The University of Tennessee (UT) has several simulation software packages including ARENA and EXTEND, and the Department of Industrial Engineering has a Simulation Laboratory for teaching students the application of these softwares. Dr. Sawhney is the Director of the Simulation Laboratory. The product of this task will be a simulation model that represents the various functions of a seaport on a computer with regard to container movement and inspections/checks that are being made for identifying a dangerous container. Simulation models are very suitable for the purposes of experimentation. The behavior of various entities of the model will be associated with appropriate probabilities and mathematical functions.

**Task F: Present the findings and operation of the model to experts**

A presentation of the model framework will be made to a group of persons who are working with ports on security matters. This group will include one or more port officials. The presentation will be arranged either on UT campus or a port office.

**Task G: Write a report documenting the research work done and describing the simulation model**

A two-part report will be written. The first part will describe the various tasks performed in detail. The second part will deal with the features of the simulation model.

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**Total Budget:**    \$    Requested Amount = \$9,981.00

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**Student Involvement (Thesis, Assistantships, Paid Employment):**

A student of Dr. Chatterjee who is in the Ph. D program in the Department of Civil Engineering has been identified to participate in the proposed research. His name is Vasin Kiattikomol. This student is likely to pursue the topic for his dissertation. Additionally Dr. Sawhney, who teaches simulation courses at the graduate level, plans to use this topic in one of his classes as a class project and get the students involved in researching various aspects of the simulation model. Thus the student involvement in this proposed research is expected to be substantial.

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**Relationship to Other Projects:**

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**Technology Transfer Activities:**

The proposed research will definitely result in one or two technical papers, which will be submitted for presentation at major conferences and publication in leading journals. Both Dr. Chatterjee and Dr. Sawhney publish papers in leading journals on a regular basis. Dr. Chatterjee actively participates in several technical committees of Transportation Research Board (TRB) and Institute of Transportation Engineers (ITE), and these include freight transportation related committees. He will share the findings of this study with different groups within TRB and ITE, and other agencies such as the American Association of Port Authorities. Dr. Chatterjee already has established contacts with a few officials of US Department of Transportation who are working in areas related to the subject of this research. He will share the findings with them.

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**Potential Benefits of Project:**

The research project will produce a report documenting all the issues related to the inspection of imported containers, which will be identified during the course of the study along with the methodology used for analysis. This report will provide information that will be useful to port officials for improving the inspection and verification processes. Further, a simulation model's framework utilizing the platform of a simulation software package will be developed. The framework can be refined and developed later into an operational software, which can be used by different ports to examine various scenarios and assess the effectiveness of strategies related to the screening of incoming containers from other countries.

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**TRB Keywords:**

Seaports, Vulnerability Analysis, Marine Containers, Terrorism